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ABSTRACT

In order to investigate the nature of metaphoric generation, comprehension, and appreciation, 8 different groups of 16 subjects were asked to rate each of 20 terms within each of 8 categories (United States historical figures, modern world leaders, mammals, birds, fish, airplanes, land vehicles, and ships) on 21 scales such as "warlike peaceful," "noble ignoble," and "strong weak." Data indicate a corresponding set of dimensions for the 8 categories, including "prestige" and "aggression." It is proposed that a metaphor is comprehensible to the extent that the distance is small between tenor and vehicle in both the superimposed within-subspace and the between-subspace, but that metaphor is aesthetically pleasing proportional to the smallness of the within-subspace distance and the largeness of the between subspace distance. Results of two further experiments document the empirical claims made by the two aspects of the theory. (Implications are drawn regarding metaphor, induction, and social policy, particularly with regard to problem-setting, and correspondence is noted between the results of this study and those of previous investigations at the macroscopic level.) (DF)

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Metaphor, Induction, and Social Policy:
The Convergence of Macroscopic and Microscopic Views

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Metaphor can be studied in many different ways and at many different levels. In his lucid and enlightening analysis of "Generative metaphor: A perspective on problem-setting in social policy," Donald A. Schon has reached through macroscopic analysis many of the same conclusions we have reached through microscopic analyses of metaphor and induction. This paper discusses the sources of convergence. The paper is divided into three main sections. In the first, we describe the motivation, approach, theory, and

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methods underlying our research on metaphor and its relationship to induction. In the second section, we point out the convergences between Schon's viewpoint and our own. In the third section, we draw some conclusions, showing in particular how our proposed theories of structure and process in metaphor address fundamental questions about the nature of metaphor. The apparent convergence of Schon's views and our own suggests that an understanding of metaphor can be attained that is independent of the means used to attain that understanding.

Abstract

Metaphor can be studied in many different ways and at many different levels. In his lucid and enlightening analysis of generative metaphor, Donald A. Schon has reached through macroscopic analysis many of the same conclusions we have reached through microscopic analyses of metaphor and induction. This paper discusses the sources of convergence. The paper is divided into three main sections. In the first, we describe the motivation, approach, theory, and methods underlying our research on metaphor and its relationship to induction. In the second section, we point out the convergences between Schon's viewpoint and our own. In the third section, we draw some conclusions, showing in particular how our proposed theories of structure and process in metaphor address fundamental questions about the nature of metaphor. The apparent convergence of Schon's views and our own suggests that an understanding of metaphor can be attained that is independent of the means used to attain that understanding.

Metaphor, Induction, and Social Policy: The Convergence of Macroscopic and Microscopic Views

Metaphor can be studied in many different ways and at many different levels, any one of which may lead to valid insights into the nature of metaphoric generation, comprehension, and appreciation. The insights of any one approach to metaphor are perhaps most convincingly validated when they converge with the insights of a distinctly different approach, leading the student of metaphor to much the same conclusions without regard to the particular method from which the conclusions derived.

In his lucid and enlightening analysis of generative metaphor, Donald A. Schon has reached conclusions strikingly similar in many ways to those we have reached in our analyses of metaphor and induction. As anyone might expect where two independent research programs are involved, there are a number of theoretical issues that are addressed by one research program but not by the other. But in the central core of overlapping issues, there is clear convergence in the conclusions we have independently drawn. In this paper, we would like to point out and discuss the sources of convergence.

The remainder of this paper is divided into three sections. In order to relate our work to Schon's, it is necessary in the first section to say something about the motivation, approach, theory, and methods that underlie our work on metaphor and induction. These underpinnings of our research differ in many respects from Schon's. Then it is possible in the second section to draw parallels between our conclusions and those of

Schon regarding metaphor, induction, and social policy. In the third section, we restate five basic questions about metaphor posed by Verbrugge and McCarrell (1977) and by Schon, and discuss how they are answered, or at least addressed, within our view of metaphor.

Metaphor and Induction

This section is divided into three parts. In the first two, we describe two different lines of research that address the relationship between metaphor and induction in somewhat different ways. In the third part, we discuss how the theoretical points of view from the two lines of research can be integrated.

Theory of Representation[1]

In this part of the paper, we discuss a theory of representation in metaphor (see Tourangeau & Sternberg, forthcoming). The discussion deals with four topics, namely, the motivation, approach, theory, and methods underlying this work.

Motivation. The basic goals motivating the research are, first, to use a representation for information in semantic memory that is flexible enough to handle metaphors in a variety of domains, second, to propose a small set of rules that accounts for the differential aesthetic appeal and comprehensibility of metaphors, and third, to relate the representation and set of rules operating upon the representation to their counterparts in a fairly general theory of induction.

Approach. Our approach to the problems listed above is in many respects an outgrowth of research on analogical reasoning done by Rumelhart and Abrahamson (1973).[2] These investigators began with the assumption that information can be represented by means of a multidimensional semantic

space in which each dimension represents some graded characteristic of the set of lexical items under consideration. Some limited support for this assumption had been obtained earlier by Henley (1969) in her study of the semantics of animal names. Henley had subjects rate the dissimilarities between all possible pairs of 30 animal names, and then used a multidimensional scaling program to derive a three-dimensional solution that seemed adequately to represent these terms. The three dimensions of the space (in order of appearance and therefore "strength" in the solution) were size, ferocity, and humanness. Animals like giraffe and elephant were near one extreme on the size dimension, whereas animals like mouse and rabbit were near the other extreme. The ferocity dimension contrasted animals like tiger and gorilla with those like pig and cow, and the humanness dimension contrasted animals like monkey and gorilla with those like cow and mouse.

According to Rumelhart and Abrahamson, each term of an analogy problem can be represented by a point in this three-dimensional semantic space. For any analogy problem of the form A : B :: C : ?, there is a concept, I, that is the ideal solution to the analogy in the sense that the vector distance from C to I is the same as that from A to B. The probability of choosing an answer option, X_i, as the best solution to the problem is a monotonic decreasing function of the distance between the locations in the space of I and X_i. Consider, for example, the analogy RAT : PIG :: GOAT : _____ (A) CHIMPANZEE, (B) COW, (C) RABBIT, (D) SHEEP. There is no animal among these options, or in the semantic space, for that matter, that falls exactly where an ideal solution should. But the animal closest in the space to this hypothetical ideal animal is cow,

followed by sheep, then rabbit, and then chimpanzee. So if subjects are asked to choose the best solution, the largest proportion of subjects should choose cow, then sheep, then rabbit, and then chimpanzee.

The theory of response choice was strengthened by assuming the applicability of Luce's (1959) choice axiom, and by assuming that the probability of choosing an alternative, X_i, as best is an exponentially decreasing function of the distance of that alternative from the ideal point. Thus, a quantitative choice rule is added to supplement the qualitative specification of rank order. With a little bit of mathematics, one can extend the quantitative predictions to all rank orderings, so that if subjects are asked not only to select the best option, but to rank order all the options as well, it is possible to predict the proportion of subjects assigning each rank ordering to each option.

Rumelhart and Abrahamson tested their theory in three ingenious experiments, of which only the first will be briefly summarized here. The authors asked 35 subjects to solve 30 animal name analogies, rank ordering the options for goodness of fit. The authors then estimated a single parameter for the exponential function, and tested the ability of the mathematical model to account for the response-choice data. In fact, the model provided an excellent fit to the data, suggesting that subjects were indeed following a rank ordering strategy similar to that proposed by the theory.

We have suspected that a common set of processes and strategies underlies performance on a variety of induction tasks (see, for example, Chapter 13 of Sternberg, 1977b), and so it seemed possible that the same choice rule could be applied to other induction tasks as well. This

possibility was investigated experimentally (see Sternberg & Gardner, forthcoming). Sternberg and Gardner administered 30 animal name analogies, 30 animal name series completions, and 30 animal name classifications to 30 students from the Yale community. The analogies were those from Experiment 1 of Rumelhart and Abrahamson (1973). The series problems took the form exemplified by the problem, RABBIT : DEER : _____ (A) ANTELOPE, (B) BEAVER, (C) TIGER, (D) ZEBRA. Subjects were asked to rank order the options in terms of how well they completed a series from the first term to the second and from the second term to the third. The classification problems took the form exemplified by the problem MOUSE, CHIMPANZEE, CHIPMUNK, _____ (A) GORILLA, (B) RAT, (C) SQUIRREL, (D) ZEBRA. Subjects were asked to rank order the options in terms of how well they fit in with the three terms preceding the options.

It was hypothesized that in each of the three tasks, subjects would employ a different strategy that was nevertheless aimed at a common goal: the discovery of an ideal point. The strategies can be conceptualized geometrically in terms of the "construction of vectors." In the analogies task, subjects would construct a vector from the first term to the second, and then attempt to construct a vector from the third term to an ideal point such that the new vector was parallel to the first vector and equal to it in length and direction. In the series completion task, subjects would construct a vector from the first term to the second, and then construct a vector from the second term to an ideal point such that the new vector was collinear with the first vector and equal to it in length and direction. In the classification task, subjects would construct a vector from the first term to the second, another vector from the first term to

the third, and a final vector from the second term to the third, and then use the centroid of the triangle formed by these vectors as an ideal point. Thus, although the proposed strategies required to arrive at an ideal point differed across the three types of tasks, it was hypothesized that subjects would indeed construct an ideal point in each task, and that the rule by which the subjects rank ordered responses (by relating them to the ideal point) would be the same in each task.

A single exponential parameter was estimated from the response-choice data for each task, and the values from the three estimations were remarkably similar. Moreover, the identical mathematical model provided an excellent fit to the data in each of the three tasks. Apparently, then, Rumelhart and Abrahamson's extension of Luce's choice axiom to the analogies task can itself be extended to other forms of induction tasks as well.

We have viewed metaphoric comprehension and appreciation as inductive in nature, because these global processes seem to involve, at bare minimum, induction of the relationship(s) between the tenor and vehicle of the metaphor. It therefore seems plausible that an approach similar to that employed in the animal name induction study might be useful in investigating metaphor. Certain problems need to be dealt with, however. First, although the multidimensional scaling paradigm might work well enough in well-delineated semantic fields such as animal names, it seemed less likely to work well, or at least to yield comparable dimensions, across a variety of semantic domains. Second, it seemed necessary to us to generalize the notion of semantic space by introducing a concept of "orders" of spaces in order to accommodate our theory of metaphoric comprehension and appreciation.

These orders represent the level of abstraction of the terms in the various spaces. It is to this theory that we now turn.

Theory. Imagine an array of "local subspaces" comprising sets of terms such as U.S. historical figures, modern world leaders, mammals, birds, fish, airplanes, land vehicles, and ships. Each local subspace represents the terms within it as points with coordinates on each of several dimensions. Each of these local subspaces might also be viewed as of roughly the same order (level of abstraction), and as of a lower order than a higher-order hyperspace that contains the lower-order subspaces, as points embedded within it. Thus the points of the higher-order hyperspace map into the lower-order subspaces, and can be labeled by the names of these subspaces. This hyperspace can in turn be viewed as one of multiple subspaces of some still higher-order hyperspace. But possible hyperspaces of successively higher orders will not concern us here; we will need to deal only with local subspaces of a lower order and one hyperspace of a higher order.[3]

We will also need some rule for restricting the subspaces that map into a single hyperspace, and some way of establishing comparability across subspaces. Both of these goals can be accomplished by requiring all subspaces to have at least one corresponding dimension.[4] Thus, for example, the subspaces of modern world leaders, bird names, and ships must have at least one corresponding dimension if they are to be local subspaces of the same order and of a common hyperspace. The conventional multidimensional scaling paradigm of requiring, say, dissimilarity ratings between all possible pairs of elements within each of these domains does not seem likely to fill the bill. Viewed in isolation, the domains simply do not seem to bear much resemblance to each other. One possible solution to this problem would be to have subjects rate dissimilarities between all

possible pairs of objects both within and between domains, although this procedure quickly becomes impractical with large numbers of objects; moreover, the theoretical status of the cross-domain ratings would have to be thought out. We have followed another alternative, drawing upon the success of Osgood, Suci, and Tannenbaum (1957) and others in achieving uniform dimensions across domains using the device of the semantic differential.

Subjects were asked to rate each of 20 terms within each domain on 21 scales such as warlike-peaceful, noble-ignoble, and strong-weak, with a different group of 16 subjects supplying ratings for each of the 8 domains. We hoped in this way to obtain a corresponding set of dimensions for the 8 domains (U.S. historical figures, modern world leaders, mammals, birds, fish, airplanes, land vehicles, ships). It seemed plausible to us that at least two such corresponding dimensions would obtain: prestige (similar to Osgood et al.'s evaluative dimension) and aggression (similar to Osgood et al.'s potency or activity dimensions). The adjective pairs for each domain were then factor analyzed.[5]

Visual inspection of the results of the factor analyses supported our hypothesis: Two corresponding dimensions of prestige and aggression appeared for each domain, although the order in which the two dimensions appeared was variable across domains. In order to confirm our visual impression, we computed correlations between the loadings of the adjective pairs on dimensions we believed either to correspond or not to correspond across domains. Correlations for corresponding dimensions ("prestige" or "aggression" in both domains) were very high, and correlations for non-corresponding dimensions ("prestige" in one domain and "aggression" in the other) were very low, suggesting that the dimensions did indeed have the statistical properties our visual inspection had suggested they should have.

A separate group of 30 subjects rated the 8 domain names on each of the 21 adjective scales, and these results were also factor analyzed, giving us a 3-factor hyperspace with each factor roughly representing a type of content (types of people, types of animals, types of vehicles). The results from this and the preceding factor analyses served as the representational basis for our further theoretical work.

Given our representational framework, what rules might identify metaphors that are either easily comprehensible or aesthetically pleasing? It seems that two basic considerations need to be made in assessing the comprehensibility and aesthetic quality of a metaphor: the superimposed within-subspace distance between tenor (first term) of the metaphor and the vehicle (second term), and the between-subspace distance.

Consider first the meaning of "superimposed within-subspace distance." Since at least two dimensions are corresponding for each domain, one can imagine superimposing the dimensions of one local subspace onto the corresponding dimensions of another local subspace. Once this superimposition is accomplished, it is also possible to imagine computing the superimposed within-subspace distance between two points that are actually in different subspaces. One simply computes the distance between points as though they were in the same subspace. Thus, if the coordinates of some point in one subspace were (x,y), then the superimposed within-subspace distance to some point in another subspace would be 0 if that point also happened to occupy location (x,y), and would depart from 0 as the Euclidean distance of that point from (x,y) increased.

An example may help clarify the concept. The superimposed within-subspace distance from the term wildcat to the term hawk is very small, because the coordinates of hawk in the bird name subspace are very close

to those of wildcat in the mammal name subspace. The superimposed within-subspace distance from wildcat and robin is quite large, however, because the coordinates of wildcat and robin are quite disparate. Similarly, the superimposed within-subspace distance from wildcat to ICBM is small, whereas the superimposed within-subspace distance from wildcat to blimp is large.

Consider next the meaning of "between-subspace" distance. In order for the concept to have meaning, it must be possible somehow to compute the distance between a pair of subspaces. This computation is possible, in our representational formulation, because the distance between two subspaces is equal to the distance between the corresponding points within the appropriate hyperspace. Thus, if the coordinates of some local subspace in the hyperspace are (x,y), the distance from that subspace to another subspace increases as the Euclidean distance of that subspace from (x,y) increases.

Let us return to our earlier example to illustrate the concept of between-subspace distance. The between-subspace distance from wildcat to hawk is the same as that from wildcat to robin, since both hawk and robin are in the same local subspace. This distance is small, since mammal and bird names are viewed as relatively close to one another in the hyperspace. The between-subspace distances from wildcat to ICBM and blimp are also the same, since these latter two terms fall within the same local subspace; and this distance is relatively large, since mammal names and names of airplanes are viewed as relatively far from one another in the hyperspace.

Turning now to the theory of metaphor, we propose that a metaphor is

comprehensible to the extent that both the superimposed within-subspace distance and the between-subspace distance between tenor and vehicle are small. A metaphor is aesthetically pleasing to the extent that the superimposed within-subspace distance is small, but the between-subspace distance is large. Thus, a smaller superimposed within-subspace distance between tenor and vehicle works in favor both of comprehensibility and aesthetic pleasingness, whereas a smaller between-subspace distance works in favor of comprenensibility, but against aesthetic pleasingness.

Consider some example metaphors derived from the terms discussed above:

(1) A wildcat is a hawk among mammals.

(2) A wildcat is a robin among mammals.

(3) A wildcat is an ICBM among mammals.

(4) A wildcat is a blimp among mammals.

What empirical claims does the proposed theory make about each of these metaphors?

A first set of empirical claims addresses the relative comprehensibility of the various metaphors. According to the theory, (1) should be a highly comprehensible metaphor, because both the superimposed within-subspace distance and the between-subspace distance between tenor and vehicle are small. Metaphor (4), on the other hand, should be only poorly comprehensible, because both distances are large. Thus, whereas it is easy to discern relations between a wildcat and a hawk, it is difficult to discern relations between a wildcat and a blimp. Metaphors (2) and (3) should be intermediate in comprehensibility, since in each case, one distance is small but the other is large. Wildcat and robin occupy

locations that are remote with respect to each other in their respective subspaces, but they are located in subspaces that are relatively close to one another (as measured by distance within the hyperspace). Conversely, wildcat and ICBM occupy locations in their respective subspaces that are quite close to one another, but they are located in subspaces that are relatively remote from one another. The qualitative assumptions of the theory do not distinguish between the comprehensibility of (2) and (3), although the experiments described below will enable us to assign quantitative weights to the use of superimposed within-subspace distance and between-subspace distance in judgments of metaphoric comprehensibility. Our strong expectation is that the former distance will carry a larger weight than the latter one--that larger superimposed within-subspace distance is more destructive to the comprehensibility of a metaphor than is larger between-subspace distance. If this expectation proves to be correct, then (3) will be judged as more comprehensible than (2). To summarize, the metaphors as ordered from most comprehensible to least comprehensible are (1), (3), (2), (4).

A second set of empirical claims addresses the relative aesthetic pleasingness (or quality) of the various metaphors. According to the theory, (3) should be the metaphor of highest quality, since although wildcat and ICBM are quite close to one another in terms of superimposed within-subspace distance, they are from distant local subspaces. Metaphor (2) should be lowest in quality, because the tenor and vehicle occupy discrepant positions in their respective subspaces, and are from proximal subspaces. Metaphors (1) and (4) should be intermediate in quality. Again, we expect superimposed within-subspace distance to carry more weight than

between-subspace distance. Hence, we expect metaphor (1) to be perceived as higher in aesthetic quality than metaphor (4), since the greater superimposed within-subspace distance should be more destructive to the quality of the metaphor than the lesser between-subspace distance. To summarize, the metaphors as ordered from most to least aesthetically pleasing are (3), (1), (4), (2).

Although the theory we are advancing may well not apply to all metaphors of all kinds, we do believe that it is fairly general, and applicable to metaphors whose tenor and vehicle may not be from obvious semantic subspaces (like mammal names or modern world leaders). Donne's famous metaphor (or conceit) linking lovers to stiff twin compasses, for example, is not readily comprehensible, according to our theory, because although the superimposed within-subspace distance between lovers and stiff twin compasses is small (at least within the context of "A Valediction: Forbidding Mourning"), the between-subspace distance is large. But it is precisely this pair of properties that renders the metaphor so aesthetically pleasing and, ultimately, so memorable. "The moon is a ghostly galleon" has also survived (perhaps too long!) because although one does not usually link heavenly bodies to ships at sea (large between-subspace distance), one can easily visualize an eerie orb sailing through the sky, impervious to the demands made upon ordinary sailing vessels.

At the opposite end of the spectrum, the theory can also explain why some statements are utter failures as metaphors. A literal statement or definition such as "An ICBM is an intercontinental ballistic missile" fails as a metaphor because although ICBM and intercontinental ballistic missile occupy identical locations within their respective local subspaces (and

hence the superimposed within-subspace distance is 0), the subspaces are identical (and hence the between-subspace distance is also 0), so that whereas satisfaction of one criterion for a good metaphor is maximized, satisfaction of the other criterion is minimized. An anomalous statement equating two seemingly unrelated concepts, such as "An ICBM is a hay stack," fails as a metaphor because although ICBM and hay stack come from subspaces that presumably are quite distant from one another, their locations in these subspaces are quite discrepant.

Our theory may require supplementation in order fully to account for either the comprehensibility or aesthetic quality of certain metaphors. For example, we are attracted to Ortony's notion (this volume) that good metaphors tend to be those in which salient properties of the vehicle are linked to nonsalient properties of the tenor. In our representational framework, the relative salience of a property is a function of the relative order in which that property emerges as a dimension. In a standard principal component or factor solution, factors are ordered in terms of their relative strength in accounting for variation in the data. Stronger (more salient) dimensions appear earlier. It would be possible to supplement our proposed theory (although we have not yet done so) with weights that take into account the possible interaction between the order in which a dimension appears and its role in the metaphor. Dimensions establishing the principal correspondence between tenor and vehicle (that is, the earliest corresponding dimensions) would be weighted as contributing to the goodness of the metaphor if they were both early dimensions of the vehicle and later dimensions of the tenor; dimensions would be weighted as contributing to the badness of the metaphor if they were both early

dimensions of the tenor and later dimensions of the vehicle. An aesthetically pleasing metaphor, then, would be one in which the principal correspondence is between an earlier dimension of the vehicle and a later dimension of the tenor.

It should be pointed out that our theory is only one of a class of theories that may be derived from the general representational framework we have proposed. One could imagine alternative theories in which either superimposed within-subspace distance or between-subspace distance are weighted zero, or in which predictions about which way these distances should go are either opposite or orthogonal to our own predictions. An appealing alternative to our hypothesis regarding the relation between between-subspace distance and aesthetic quality of a metaphor has been suggested by Michael Gardner. His suggestion is that the function is curvilinear rather than linear: The best metaphors are ones in which the between-subspace distance is moderate. If the distance is too small, the connection appears to be trivial, but if the distance is too large, the connection appears to be remote; or possibly, after a certain point, the dimensions cease to match up at all. One might imagine a rubber band stretched further and further, until it snaps: Beyond a certain distance, the metaphor simply can't withstand the strain. To summarize, the representational framework is flexible enough to accommodate a variety of rules for operating upon that framework, but is not so flexible as to be vacuous: It does make empirical claims as to what kinds of distances should affect the comprehensibility and quality of a metaphor.

Experimental methods. We are conducting two experiments designed to test some of the empirical claims and implications of the theory described

above (Tourangeau & Sternberg, forthcoming). Each of the experiments looks at the theory in a slightly different way.

In the first experiment, subjects are presented with 64 metaphors, such as "A wildcat is a hawk among mammals," and are asked to rate, among other things, the aesthetic quality or comprehensibility of each metaphor. The basic independent variables for predicting these two dependent variables (via multiple regression) are superimposed within-subspace distance and between-subspace distance. Other variables, such as the dimensional salience variable mentioned earlier, may also be considered if the initial two appear to need supplementation. Each subject also receives two ability tests, one measuring skill in verbal analogical reasoning (e.g., PATIENT : CLIENT :: _____ (A) SURGEON : ACTOR, (B) HOSPITAL : PENITENTIARY, (C) DOCTOR : LAWYER, (D) TUBERCULOSIS : FELONY) and the other measuring skill in judging the quality of poetry (Rigg, 1937). Subjects are presented with two passages of poetry, one by a famous poet, the other (doggerel) by the author of the test, and are asked to select the better verse. We plan to use the tests to determine whether individual differences in measured verbal abilities are predictive of differences in parameters of the model (i.e., differential weights assigned by individual subjects to the superimposed within-subspace distance and the between-subspace distance).

In the second experiment, subjects are divided into two groups, each of which receives one of two types of items. In both groups, subjects receive a metaphor in which a tenor is supplied, but the vehicle is missing. Subjects in one group are offered four alternative vehicle completions, all from the same local subspace. The subjects' task is to rank order these completions in terms of their aesthetic quality. Subjects in the

other group are also offered four alternative vehicle completions; the completions are each from a different local subspace, but they are approximately matched in terms of their locations within their local subspaces. Thus, the alternatives in the items presented to the first group are at an approximately constant between-subspace distance from the tenor, but at a variable superimposed within-subspace distance; the alternatives in the items presented to the second group are at an approximately constant superimposed within-subspace distance from the tenor, but at a variable between-subspace distance. The theory makes clear qualitative predictions regarding the rank orders subjects should give for each type of item: Lower ranks (signifying better metaphors) should be assigned to completions that minimize superimposed within-subspace distance and maximize between-subspace distance. In these studies, it is possible to supplement the qualitative predictions with quantitative predictions as well. By extending the Rumelhart-Abrahamson adaptation of Luce's choice axiom to the present situation, we hope to predict the proportion of subjects who should assign each ranking to each option. If this application of the choice axiom is successful, then it will appear that the same decision rule that is used in a variety of induction tasks (analogies, series completions, and classifications) is used in the metaphor task as well. Indeed, metaphor comprehension and evaluation might then be viewed as inductive processes in much the same way that analogical, serial, and classificational reasoning are. The induction can proceed either from tenor to vehicle or from vehicle to tenor. Thus, the second experiment might equally have been conducted (and further research will be conducted) in such a way that the tenor rather than the vehicle is missing. Such a study, in

addition to testing the generalizability of the theory from both ends of the metaphor, would enable one to investigate Ortony's (1978) hypotheses regarding asymmetry in metaphor.

Theory of Information Processing[6]

The theory of representation described above addresses itself to the form in which information is represented, and to rules that act upon that form of representation. It does not, however, specify an information-processing model for metaphoric comprehension and appreciation. In this part of the paper, we discuss a theory of information processing in metaphor (see Nigro & Sternberg, forthcoming). This discussion, like the preceding one, deals with four topics, namely, the motivation, approach, theory, and methods underlying our work.

Motivation. The basic goals motivating our research parallel those in the research on representation. These goals are, first, to construct a theory of information processing that is flexible enough to handle metaphors in a variety of domains; second, to propose a small set of processes that accounts for time to comprehend and evaluate metaphors, in conjunction with rules that explain why some metaphors are more easily comprehended or more highly regarded than others; and, third, to relate the information processes to their counterparts in a fairly general theory of induction.

Approach. Our approach to the problems listed above is in many respects an outgrowth of earlier research on analogical reasoning (Sternberg, 1977a, 1977b). Thus, the approach to information processing, like the approach to representation, began with a theory of analogical reasoning, although the two theories of analogical reasoning (Rumelhart &

Abrahamson's and Sternberg's) deal with virtually nonoverlapping theoretical issues.

According to the "componential" theory of analogical reasoning, solution of analogies of the form A : B :: C : $D_1 \ldots D_k$ is accomplished through the execution of up to six component processes. Consider as an example the analogy, WASHINGTON : ONE :: LINCOLN : (A) TEN, (B) FIVE. The individual solving this analogy must encode the terms of the problem, identifying the terms and retrieving from long-term memory the attributes and values that may be relevant for analogy solution. The individual must also infer the relation between the first two analogy terms, ascertaining what it is that Washington and one have in common (e.g., that Washington was the first president, or that Washington is the portrait on a one-dollar bill). Next, the individual must map the relation from the first term to the third, recognizing what it is that links the domain (or first half) of the analogy, which is about Washington, to the range (or second half) of the analogy, which is about Lincoln. Then the individual must apply the inferred relation as mapped to the range of the analogy from the third analogy term to each answer option, determining which option bears the same relation to Lincoln that one does to Washington. Optionally, the individual may need to justify one of the options as preferred, but nonideal. The individual may find, for example, that neither option meets his or her criterion for an acceptable response, and therefore may need to check previous operations to determine whether there were any errors of omission or commission. An example of an error of omission would be one in which the individual inferred the ordinal position of Washington's presidency, but failed to infer that Washington is the portrait on a one-dollar

bill. An example of an error of commission would be one in which the individual believed that Lincoln is the portrait on a two- rather than a five-dollar bill, and thus failed in application. Finally, the subject must respond, communicating his or her answer choice.

This theory was tested in a series of three experiments using schematic-picture, verbal, and geometric analogies (Sternberg, 1977b). Subjects were asked to solve analogies of varying difficulty and content under various experimental conditions that permitted isolation of the hypothesized component processes. The results of the experiments lent strong support to the theory, suggesting that response times to analogies of various types can be viewed as the sum of the times spent on each of the component processes specified by the componential theory of analogical reasoning.

It seemed plausible that this information-processing theory of analogical reasoning, like the Rumelhart-Abrahamson theory of representation and response choice, could be extended to other induction tasks as well. So in a series of nine experiments, the generalizability of the theory has been tested on analogies, series completions, and classifications with schematic-picture, verbal, and geometric content (Sternberg, forthcoming). A typical classification problem took the form:

(A) N.J., N.Y. (B) N.C., S.C.

PA.

The subject's task was to determine whether the target item, here, Pa., belonged more appropriately in category A or in category B. According to the componential theory of induction, the individual must encode the terms of the problem, infer the relation between N.J. and N.Y., infer the relation

between N.C. and S.C., map the differences that distinguish between the two categories, apply this relation to Pa. to determine in which category Pa. belongs, optionally, justify one of the categories as preferred, and then respond. A typical series completion problem took the form:

LOUIS XIII, LOUIS XIV, LOUIS XV

TRUMAN, (A) EISENHOWER, (B) ROBESPIERRE.

The subject's task was to determine which of the answer options should follow the last term, here, Truman, in the series. Subjects must recognize the relation of succession for the French kings, and then use this relation of succession for American presidents. According to the theory, the individual must encode the terms of the problem, infer the relation between Louis XIII and Louis XIV, infer the relation between Louis XIV and Louis XV (using only those attributes that are still deemed relevant after the first inference between Louis XIII and Louis XIV), map the relation from Louis XV to Truman, apply the inferred relation as mapped to the range of the problem from Truman to each answer option, optionally, justify one of the answer options as preferred, and finally, respond. To summarize, the same component processes seem to be involved in the solution of each of the three kinds of induction problems. Might these same processes be involved in metaphoric understanding and appreciation? The information-processing theory about to be described suggests that they are.

Theory. We propose that the componential theory of induction can be extended to the comprehension and evaluation of metaphors (Nigro & Sternberg, forthcoming). What are the processes involved in comprehending and evaluating metaphors? Consider the metaphor, "Bees in a hive are a Roman mob (a) in the streets, (b) in the coliseum." The individual faced with a

choice between the two completions must encode the terms of the metaphor, infer the relation between bees and hive, map the relation between bees and a Roman mob, and apply the inferred relation from a Roman mob to in the streets and in the coliseum.[7] Presumably, the individual will choose the latter as the preferred completion because a coliseum encloses a multitude in a way somewhat analogous to the way a hive encloses a multitude. Neither completion seems ideal, however, so that the individual may spend some time justifying in the coliseum as preferred but nonideal. Finally, the individual responds. Thus, the metaphor considered here is analogical in nature, and seems to require the same processes to comprehend it as does an analogy.

Not all metaphors are stated in analogical form. For example, the metaphor "My head is an apple without a core" is missing a term. The individual attempting to comprehend the metaphor must infer the relation between apple and core, map from apple to head, and then apply the previously inferred relation to head, completing the metaphor with the missing brains (or some such). In this metaphor, comprehension requires insertion rather than selection of a missing term. Consider four variants of the "bees and Romans" metaphor:

(1) Bees in a hive are a Roman mob in the coliseum.

(2) Bees in a hive are a Roman mob.

(3) Bees are a Roman mob in the coliseum.

(4) Bees are a Roman mob.

In the first metaphor, all terms are supplied. In the second and third metaphors, one term is missing, and in the fourth metaphor, two terms are missing. What effects do the missing terms have upon the comprehensibility

and aesthetic quality of the metaphors? We believe, with Miller (this volume), that when terms are deleted, the individual must insert the missing terms, attempting to place constraints upon the metaphor that render it interpretable. Deleting terms decreases the ease with which the metaphor is comprehended because of the extra cognitive processing involved in the generation of missing terms. If the subject is unable to insert missing terms, or inserts inappropriate missing terms, comprehension may be thwarted altogether. Deleting terms, however, is proposed to increase the aesthetic quality of the metaphor. Part of what makes a metaphor pleasing, we believe, is the insertion of the missing terms or constraints. Part of the beauty of Donne's metaphor linking lovers to stiff twin compasses, for example, seems to derive from the cognitive work required to insert the links between lovers and stiff twin compasses. In the language of the theory of representation stated earlier, this work is expended toward bridging the between-subspace distance. Appreciation of a metaphor requires a certain amount of active participation on the part of the comprehender that is reduced in the interpretation of literal statements (where the between-subspace distance is zero or close to it), and this active participation, we believe, cannot be separated from any beauty that may be "inherent" in the metaphor. As mentioned earlier, the perceived beauty of the metaphor may only increase with between-subspace distance up to a certain point, beyond which the metaphor may become utterly opaque. This point seems likely to differ for different individuals. The preferred distance between tenor and vehicle may be greater for highly verbal or trained individuals than for modestly verbal or trained individuals. Active participation contributes to the

beauty of a metaphor only if the participation is in the bridging of between-subspace distance. Greater superimposed within-subspace distance can only destroy the beauty of a metaphor.

To summarize, the information-processing theory proposed here, like the representational theory proposed earlier, derives from a theory of analogical reasoning that was first extended to series completion and classification tasks, and then to metaphor. The proposed theory is flexible enough to accommodate a variety of types of metaphors, but not so flexible as to fail to make well-specified empirical claims. This theory, like the representational theory, is only in the earliest stage of testing, and is thus readily subject to change if the data demand it. It is to a description of two initial experimental tests of the theory that we now turn.

Experimental methods. In a first experiment, designed to isolate the components of information processing (Nigro & Sternberg, forthcoming), subjects are presented with metaphors such as "Bees in a hive are a Roman mob _____ (a) in the streets, (b) in the coliseum." Subjects are asked to select the preferred completion as quickly as they can while still making a carefully reasoned choice. The metaphors are always presented in trials consisting of two parts. The second part always consists of the full metaphor. The content presented in the first part differs as a function of the experimental condition. Each subject receives half the metaphors in each of two conditions. In the first condition, the first part of the trial consists merely of presentation of a blank field. Subjects press a button when they are ready to see the full metaphor. After they press the button, the full metaphor appears immediately, and the subjects

solve it as quickly as they can. In the second condition, the first part of the trial consists of presentation of the first half of the metaphor, for example, "Bees in a hive." Again, subjects press a button when they are ready to see the full metaphor, and the metaphor appears immediately after the button is pressed. The purpose of having the two conditions is to enable us to separate component processes that otherwise would be confounded. (See Sternberg, 1977b, for the rationale of componential task decomposition.) Subjects also receive tests of verbal reasoning, including a standard analogies test, which are used to assess the extent to which individual differences in component information processing in the metaphorical reasoning task are related to individual differences in verbal and particularly verbal analogical reasoning ability.

In a second experiment, designed to investigate the determinants of metaphoric comprehensibility and pleasingness, subjects are presented with metaphors taking the four forms described earlier for the "bees and Romans" metaphor. Although each metaphor is presented in each of the four forms, a given subject sees a particular metaphor in only one of the four forms. Each subject receives equal numbers of metaphors in each of the four forms. The subject's task is to rate either the aesthetic quality or the comprehensibility of each metaphor presented to him or her. A given subject supplies only one kind of rating. Unbeknownst to the subjects, they are being timed while making their ratings. Our expectations are that (a) aesthetic quality will decrease with increasing numbers of explicitly presented terms, (b) comprehensibility will increase with increasing numbers of explicitly presented terms, and (c) time to respond will decrease with increasing numbers of explicitly presented terms, despite

the slightly increased reading load, because of the reduced amount of cognitive work required; i.e., there is less need to insert missing terms.

Integration of Theories of Representation and Information Processing

The theories of representation and information processing presented above look at metaphoric comprehension and appreciation from distinct but complementary points of view. These points of view can be integrated. In encoding, the individual locates the tenor and vehicle of the metaphor in their respective local subspaces. In inference, the subject constrains those dimensions of the tenor that are likely to be relevent. Mapping is the heart of metaphoric comprehension and appreciation: The subject "computes" the superimposed within-subspace distance and the between-subspace distance between tenor and vehicle. In application, the subject constructs or selects a completion to the vehicle that satisfies the same constraints as those inferred for the tenor. If the subject is unable to find such a completion, then justification is used to construct or select the best possible, nonoptimal completion. Finally, the subject offers whatever kind of response is required.

The comprehensibility and quality of a metaphor can be influenced in all but the last (response) stage of metaphoric reasoning. If a term is particularly difficult to encode, then the comprehensibility and aesthetic quality of a metaphor may be reduced. Terms in remote local subspaces (i.e., in remote regions of the hyperspace), terms whose coordinates are unknown, or terms that are particularly ambiguous and thus may not have a unique set of coordinates are all likely to be difficult to encode. Requiring insertion of a missing term during inference will generally decrease the comprehensibility of a metaphor while increasing its quality.

If, however, explicit constraints are presented that are highly unusual or conceptually opaque, then comprehensibility may actually be reduced by supplying the subject with the difficult-to-process constraints. Mapping is without question the major source of variance in metaphoric comprehensibility and quality: A metaphor is highly comprehensible if both superimposed within-subspace distance and between-subspace distance are small, and highly pleasing if superimposed within-subspace distance is small but between-subspace distance is large. Requiring insertion of a missing term during application will generally reduce the comprehensibility of a metaphor while increasing its quality. Requiring selection of one of several metaphoric completions, none of which is very satisfactory, will increase the amount of justification required, and reduce the comprehensibility and quality of the metaphor. To summarize, we speculate that although comprehensibility and aesthetic quality are determined primarily by the outcome of the mapping process, each is complexly determined, as the above analysis shows.

Metaphor, Induction, and Social Policy

In his analysis of generative metaphor, Schon attacks the problem of metaphor at a global level. Nevertheless, he points out that "with respect to the workings of the process itself, we need much better descriptions of the component activities [of] 'restructuring' and 'co-ordination'" (p. 000). The analysis presented in the preceding section was an attempt to provide "better descriptions of the component activities"--to analyze at a microscopic level the elements of metaphor that Schon has analyzed at a macroscopic level. There is no one correct level of analysis: Each level of analysis is capable of providing its own unique form of enlightenment.

The present section is divided into six parts. In each of the first five parts, we take one of Schon's macroscopic constructs and explicate it in terms of the more microscopic constructs proposed in the present theories. In the last part, we draw some conclusions.

Generative Metaphor

Schon conceives of the central construct in his theory, generative metaphor, as the "'carrying over' of frames or perspectives from one domain of experience to another" (p.000). Not all metaphors are generative: Some merely capitalize upon already existing ways of seeing things. A generative metaphor, however, actually generates "new perceptions, explanations and inventions" (p.000). The perception of the relation between tenor and vehicle creates in the perceiver a fresh way of viewing the nature of the tenor of the metaphor.

In our information-processing account of metaphor, the process most directly giving rise to what Schon calls generative metaphor is mapping, a term Schon himself uses. In structural terms, the perceiver sees a correspondence between a term located at a particular point in one local subspace and some other term located at the corresponding point in another local subspace. The metaphor is generative by virtue of the correspondence never having been perceived before, and thus resulting in a new perspective on the tenor of the metaphor.

Consider a few examples. A metaphor presented earlier, "A wildcat is an ICBM among mammals," might result in a new perception of a wildcat, one of a deadly hurling projectile whizzing in a long arc through the air, about to strike and destroy an unsuspecting victim. Schon cites another example of interest, "Man is a wolf." This metaphor may result in a new

or enhanced perception of man as a fierce, untamed, destructive animal, ready to pounce in an instant upon his unsuspecting victims. The example is also of interest for the structural theory proposed earlier because it calls attention to a new situation, one in which the tenor and vehicle of the metaphor seem, at least on the surface, to be at different levels of abstraction. In our implementation of the structural theory, man was at a higher level of abstraction, and thus in a higher-order space, than wolf. Wolf was an element in the local subspace of mammals, whereas man might have been considered as a higher-order space containing modern world leaders and U.S. historical figures as local subspaces. How does the structural theory handle metaphors constructed from terms of seemingly different levels of abstraction?

We believe that in comprehending this metaphor, the individual does not assign to every man (or woman) he or she has known the properties of a wolf. Man is not defined in terms of its full extensional meaning, any more than wolf is. Rather, the individual constructs two prototypes, one for man and one for wolf, that represent composites of the attributes associated with each term. Most of us today do not have highly differentiated notions about or diverse acquaintances with wolves, so that the prototype for wolf may be nothing more than an already assigned point for wolf in a single local subspace. (Among hunters, wolves might comprise a whole subspace of their own.) Man, on the other hand, is likely to be a highly differentiated concept, and the prototype may be viewed as the centroid of the points corresponding to the salient men we know or know of. The centroid need not be, and probably is not an unweighted average of coordinates. We suspect it is a weighted average, with the weights influ-

enced by context. In this case, wolf sets up a minimal context. Thus, the dimension of aggression noted earlier may well receive a higher weight than that of prestige. These prototypes are used as the basis for mapping. Note that the formation of the prototype is by what was called earlier the encoding process--that process by which the location of a point in space (in this case, the centroid corresponding to the prototype) is identified.

Problem-Setting versus Problem-Solving

Schon believes the major difficulties in social policy are in problem-setting rather than in problem-solving. The greater challenge is to frame the purposes to be achieved, rather than to select optimal means for achieving them. Schon cites case-study examples in which the way the problem was framed was largely responsible for the way in which the problem was solved. Schon's examples reminded us of Graham Allison's (1969) classic paper, in which Allison compared different frames in which the Cuban missile crisis might have been viewed, each of which suggested a different conception of the enemy (primarily the Soviet Union) and of how to deal with it. We think Schon is almost certainly correct in this regard. In his words, "problems are not given. They are constructed by human beings in their attempts to make sense of complex and troubling situations" (p.000). In terms of our proposed structural and process theories, problem-setting style can be determined by any of a number of predilections. Consider the forms individual differences in each of the component processes of metaphorical reasoning might take.

The policy-maker has a number of options in encoding the available information. First, he or she may view certain dimensions as more salient

than others. For example, some individuals seem to view the aggression dimension as particularly salient, adopting a "cold war" mentality wherever possible. Second, individuals may differ in their placements of points within a particular local subspace. For example, Brezhnev was scaled as the most aggressive of the modern world leaders included in our sample of leaders. However, Brezhnev's location in the subspace was computed as an average for the individuals supplying ratings. Some individuals might see him as less aggressive, resulting in a very different perception of him as the tenor of an implicit metaphor.

Policy-makers may also differ in their inferences about the topics of their metaphors. For example, a pacifist might be viewed either as a lion or a mouse, depending upon whether the individual constructing the metaphor inserts as implicit terms "among senators" or "in the Senate" on the one hand, or "among soldiers" or "on the battlefield" on the other. Either metaphor might be acceptable, depending upon the constraining context the individual chose to insert.

Mapping can also influence the way in which problems are set. Presumably, everyone tries to match terms as closely as possible in their respective local subspaces; but there may be substantial individual differences in preferred distances between subspaces. As was noted earlier, it seems plausible that highly verbal or literate individuals might prefer larger between-subspace distances than do less verbal or literate individuals. Similarly, some individuals may have greater vision in reaching beyond the mundane metaphors that can be formed from very close local subspaces.

Policy-makers may also differ in the constraints they apply to the

vehicle of the metaphor. To continue with an earlier example, viewing a pacifist as a lion might mean very different things depending upon whether the lion is viewed as being in its native jungle habitat or in the captivity of a cage at the zoo. A politician compared to a Spartan might be viewed either as a jingoist in the legislature or as an austere individual in his personal life, depending upon whether the Spartan is viewed in the context of the battlefield or the home.

Finally, policy-makers may differ in their tolerance of imperfection in metaphor, where imperfection is viewed in terms of the superimposed within-subspace distance between two points. Stated otherwise, policy-makers may differ in their willingness to justify as valid, metaphors of varying degrees of imperfection. Gerald Ford, for example, often compared himself to Harry Truman, a comparison that seems shaky at best. It would seem that an intermediate degree of willingness to justify metaphors as acceptable would be best. Very high willingness to justify metaphors might result in outright distortion of the facts, whereas very low willingness to justify metaphors might result in tunnel vision.

Frame-Awareness, Frame-Conflict, and Frame-Restructuring

Schon argues that there are "certain pervasive, tacit generative metaphors" that govern thinking about social policy problems, and that "we ought to become critically aware of these generative metaphors, to increase the rigor and precision of our analysis of social policy problems by examining the analogies and disanalogies between the familiar descriptions... and the actual problematic situations that confront us" (p.000). Once again, we are in agreement with Schon's position. We cannot evaluate the quality of our solutions to problems without knowing what the problem is

that we have set out to solve. And this problem is one of our own construction. We have structured external events, although we may not know how. In terms of the structural and process theories described above, we are only dimly aware (if that) of the structure and content of our various orders of subspaces, and of the operations we perform on them. Surely, the research of Nisbett and Wilson (1977) on our awareness of internal processes suggests minimal access to these processes. We would like to believe that although the internal representations and processes are not accessible to conscious introspection, they are accessible to the kinds of experimental analyses described above.

Frame-conflict, according to Schon, arises when "several different stories about the same situation" are constructed; "each story is internally coherent and compelling in its own terms but different from and perhaps incompatible with all the others" (p.000). Schon provides an example of frame-conflict, showing how an urban slum can be viewed either as blighted and decayed or as healthy and natural. In terms of our own theories, frame-conflict can arise because of different encodings of terms, different inferred constraints, different between-subspace mappings, different applied constraints, or different tolerances in justification of nonzero superimposed within-subspace distances.

Frame-conflict is resolved by frame-restructuring, in which "we respond to frame-conflict by constructing a new problem-setting story, one in which we attempt to integrate conflicting frames by including features and relations drawn from earlier stories, yet without sacrificing internal coherence or the degree of simplicity required for action" (p.000). In terms of the theories proposed earlier, there seem to be two major ways

of resolving frame-conflict. The first is to seek new encodings, inferences, mappings, applications, and justifications that resolve conflict by selective inattention to conflicting details. A frame-story is created that integrates only those features of two previous stories that are consistent with each other. The second is to create new aspects of the stories that resolve inconsistencies. For example, a sly general initially compared to a fox turns out to be ruthless on the battlefield. He is then compared to a rabid fox. An insertion further describing the vehicle restructures the metaphor to render it minimally acceptable.

A domestic example of the development of a generative metaphor may help show the course of frame-awareness, frame-conflict, and frame-restructuring. The example is one of policy-making "in the small." One of us (Sternberg) recently had to decide whether to buy a house. The major problem with the house seemed to be that its price was at the very limit of affordability; the house might therefore be difficult to maintain. This particular house happened to be located on a cul-de-sac named Wolf Tree Drive. The owners mentioned one day that a wolf tree is a tulip tree. That same day, Sternberg looked up tulip tree in Webster's Third New International Dictionary of the English Language, Unabridged, and found it to be a tree with pretty flowers resembling tulips. This definition resulted in the generation of a metaphor comparing the house to a tulip tree, a metaphor that was very pleasing. Sternberg then looked up wolf tree, and found it to be "a forest tree whose size and position cause it to prevent the growth of many small and potentially more valuable trees around it by usurping their space, light, and nourishment." This definition also led to generation of a metaphor, and an unpleasant one at that:

By buying the house, Sternberg and his wife were investing in a wolf tree that would restrict their ability to do a number of things in life that were important to them. Travel and family plans, for example, might have to be postponed because of the cost of the house. They became aware not only of the two frames, but of the obvious conflict between them. They resolved the conflict, eventually, with the discovery that the flowers of the tulip tree appear only very high up on the tree and when the tree is fully mature. They thus concluded that after a few years had passed and their financial position had become more secure, their investment would flower! They had resolved the conflict by means of the first way of resolving frame-conflict. They had ignored those aspects of the wolf tree that were inconsistent with the tulip tree. How else could they justify their decision to buy the house?

Life-Cycle of a Generative Metaphor

Schon proposes that a generative metaphor has a life-cycle all its own.

> In the earlier stages of the life-cycle, one notices or feels that A and B are similar, without being able to say similar with respect to what. Later on, one may come to be able to describe relations of elements present in a restructured perception of both A and B which account for the pre-analytic detection of similarity between A and B, that is, one can formulate an analogy between A and B. Later still, one may construct a general model for which a re-described A and a re-described B can be identified as instances. (p. 000)

Note that Schon, too, sees the construction of a metaphor as tantamount to

the formulation of an analogy. His account of the life-cycle of a metaphor is consistent in several respects with our laboratory findings regarding the "life-cycle," or information-processing model of analogy solution.

First, analytic solution of analogies via attribute-by-attribute comparison does appear to be accompanied by what has been variously called holistic processing or a preliminary scan (Sternberg, 1977a, 1977b). This processing is preanalytic in the sense that the comparison does not rely on serial, "reasoned" attribute comparisons. Thus, dual processing of both a pre-analytic and an analytic nature appears to be common to the processing of both standard analogies and generative metaphors.

Second, it has been found that in analogy solution, subjects are not only unaware of what they have mapped from the domain (first half) to the range (second half) of the analogy, but are unaware of having mapped at all! In contrast, subjects are at least marginally aware of having encoded, inferred, applied, or justified, although they are often unaware of the particular attributes they have processed. The A to C mapping in analogy solution corresponds to the A to B similarity recognition in metaphor generation referred to by Schon. In analogy solution, as in metaphor generation, one can later state the similarity relations that may have been used. Consider, for example, the analogy Washington : one :: Lincoln : five. Subjects will have no difficulty recognizing that Washington and Lincoln are similar in a number of ways. But they will not be aware of having generated these similarities during the course of analogy solution.

Third, a subject, after reflection, may well be able to describe the two terms as special cases, in the example analogy, of presidents whose

faces appear on currency. In terms of the proposed structural theory of metaphor, the subject recognizes the dimensions of similarity that overlap between local subspaces and that form the basis for mapping. The individual may even recognize the hyperspace in which the local subspaces reside. But these recognitions follow rather than precede the detection of relations that makes possible understanding of an analogy or generation of a metaphor.

Surface Metaphors versus Deep Metaphors

Schon distinguishes between surface and deep metaphors. The surface metaphor is that contained in the explicit language of a story about some object or phenomenon. But this language may not disclose what lies beneath the story.

> The "deep" metaphor, in this sense, is the metaphor which accounts for centrally important features of the story—which makes it understandable that certain elements of the situation are included in the story while others are omitted, that certain assumptions are taken as true although there is evidence that would appear to disconfirm them, and especially that the normative conclusions are found to follow so obviously from the facts. Given a problem-setting story, we must construct the deep metaphor which is generative of it. (p. 000)

How do people ascertain the deep metaphor that underlies one or more surface metaphors? We suspect people do so by filling in terms of an implicit analogy.

Consider as a first example John Dean's description of the Nixon

presidency and Dean's relation to it as told in Dean's congressional testimony. Dean conveys to President Nixon his fear of a cancer on the presidency. This surface metaphor, and the story surrounding it, seem intended to suggest a deep metaphor of John Dean as cancer surgeon. Dean's first function, in many ways the most difficult of all, is the recognition that a cancer exists. His second function is to excise the cancer, operating in a way that will remove the cancer while at the same time doing minimal damage to the patient's healthy organs. His final function is to restore the patient to an appearance of good health, stitching up any incisions that may have been made and making the patient presentable to the outside world. In this account, the blemishes signifying a cancerous state reappear because the root causes of the cancer--the internal dispositions of Nixon and the (other) men who surrounded him--were beyond the cancer surgeon's control. But an alternative reading is also possible, one of John Dean as cosmetic surgeon. As cosmetic surgeon, Dean first recognizes the appearance of external blemishes, and shows no concern for the internal malignant state that may have been responsible for these blemishes. Next, Dean performs cosmetic surgery, attempting to remove the blemishes while remaining oblivious to the internal states that may have generated them. Finally, Dean restores the patient to his preblemished appearance, substituting healthy-looking skin for the now-removed blemished skin. In this account, the blemishes quickly reappear because nothing was done to correct the internal state that generated them.

Consider as a second example the case of the White House plumbers operating during the Nixon administration. Again, there are two alternative

readings of the actions of the so-called plumbers. In the White-House sponsored reading, the plumbers were plugging leaks in the flow of information along the pipeline that conveys state secrets from one security agency (for example, the FBI) to another (for example, the CIA). Leaks in the pipeline could be disastrous to national security, and thus needed to be corrected immediately and often without much regard as to the means used to correct them. In the alternative reading, the pipeline being treated was not one between security agencies, but between informants and the press. The information traveling along this pipeline was not state secrets, but secrets damaging to Nixon's prestige and possibly his longevity as president as well. Most importantly, the proper deep metaphor was not one of plumbers plugging leaks in pipelines, but one of demolition experts blowing up the pipelines that provide information to the press and thus protect our rights under the First Amendment.

In deciding between the appropriateness of two or more alternative deep metaphors, one has to decide between the appropriateness of two or more implicit analogies. Consider the case of John Dean. The two implicit analogies are

(1) External actions of Dean : Internal state of Dean ::
External actions of cancer surgeon : Internal state of cancer surgeon

(2) External actions of Dean : Internal state of Dean ::
External actions of cosmetic surgeon : Internal state of cosmetic surgeon

The two analogies are identical in their A and B terms (domains). They differ only in their C and D terms (ranges). Thus, the major difficulty

in choosing between analogies is in deciding upon the preferred mapping from domain to range of the analogy. There are other difficulties, however. First, the A term of the analogy may be incompletely or incorrectly given: Dean's account of his actions may be wholly inadequate, and must be checked against other sources of information. Second, the content of the B term is not a given, but must be inferred from the content of the A term. But it is difficult to infer internal states from external actions. Any of a number of inferences are usually possible, and the choice of inferences may well determine the mapping that is made. Third, neither analogy can be expected to be perfect, and so the individual will have to decide which is better, and whether the better analogy is close enough to a perfect analogy to justify it as being valid. To summarize, the construction of a deep metaphor is fraught with difficulties, difficulties that can be characterized in terms of the components of the information-processing theory of analogical reasoning described earlier.

Conclusion

We have attempted to take the major concepts in Schon's broadly based and conceptually rich theory of metaphor, and to show how they relate to concepts in both the theories of metaphor and of analogy (and induction) presented in the preceding section of this paper. We believe that the major difference between Schon's research and ours is one of approach rather than substance. His approach might be characterized as macroscopic, ours as microscopic. But the commensurability of the conclusions reached by the two different approaches is a powerful argument in favor of their validity. Converging operations have led to converging conclusions, suggesting that there is a common core of knowledge that transcends specific

methodologies. With time, we can hope to see the substance of this core extended.

Conclusions

We will conclude our discussion of metaphor, induction, and social policy by re-posing five major issues in the theory of metaphor posed by Verbrugge and McCarrell (1977) and by Schon, and by showing how the theories of representation and process described in this paper deal with these issues.

One issue posed by Verbrugge and McCarrell is that of how semantic information is represented. We have proposed a spatial representation in which local subspaces can be mapped into points of higher-order hyperspaces, and vice versa. This representation is more flexible than conventional spatial representations because of its ability to characterize terms of differing levels of abstraction. We have proposed that a common set of dimensions underlies many (although almost certainly not all) of the local subspaces, and our factor analytic data were consistent with this notion.

A second issue posed by Verbrugge and McCarrell is that of what makes some metaphors more successful than others. We have proposed two rules that we believe govern successful, i.e., aesthetically pleasing, metaphors. The first is that the superimposed within-subspace distance between tenor and vehicle be minimized; the second is that the between-subspace distance be maximized (at least within that range of distances for which the dimensions of the local subspaces remain correspondent). Comprehensibility, unlike aesthetic quality, is maximized by minimization of both superimposed within-subspace distance and between-subspace distance.

A third issue posed by these authors is that of how the tenor and vehicle of a metaphor interact. There seem to be three sources of interaction in the proposed theory. The first is an interaction between superimposed within-subspace distance and between-subspace distance: Aesthetically pleasing metaphors minimize the first while maximizing the second. The second source is in the constraints placed by the inference and application processes. It has been proposed that the explicit or implicit constraints set by the context of the metaphorical sentence result in tenor and vehicle being perceived in restricted ways that delimit their possible relations to each other. The third source of interaction was not discussed in this paper for lack of space, although it is discussed elsewhere in the context of research on reasoning by analogy (Sternberg, 1977a, 1977b; Sternberg & Rifkin, in press). There exist alternative process models by which individuals can encode, infer, map, and apply attributes. At one extreme is a completely noninteractive model, in which the outcome of each operation is independent of the outcome of every other operation. At the other extreme is a completely interactive model, in which the outcome of each operation can influence the outcome of every other operation. It seems likely that metaphors are comprehended in a highly interactive way, with the results of operations mutually affecting each other.

A fourth issue, this one posed by Schon, is that of how we decide whether people are using generative metaphors, and if they are, what these generative metaphors are. In two of the experiments described above,

subjects were asked to choose among alternative completions for metaphors. Preferences could thereby be discerned. But in both of these experiments, subjects were given at least part of the metaphor as stimulus material. We have not yet attempted to infer subjects' implicit metaphors when the subjects are given no experimentally-controlled stimulus material at all.

A fifth issue, also posed by Schon, is that of discovering how people generate metaphors. The theories proposed here only begin to answer this fundamental question. We have proposed a structure and rules for operating upon this structure. In the mapping process, individuals will generate metaphors that minimize superimposed within-subspace distance and meet their preference for between-subspace distance. We have suggested that individuals may differ in this latter preference. Individuals may also differ in the ways in which they encode, infer, and apply attributes. Different encodings of an urban slum, to take Schon's example, result in very different generative metapnors. But we are certainly a long way from a full description of what leads people to generate certain metaphors, and in particular, those metaphors rather than others.

We have attempted to demonstrate in this paper a convergence between macroscopic and microscopic views of metaphor, induction, and social policy. The demonstration began with a description of the "microscopic" views we have adopted, continued with an integration of these views with the "macroscopic" views of Schon, and ended with a discussion of how the microscopic view deals with some fairly macroscopic questions about metaphoric generation, comprehension, and appreciation. The convergence of Schon's views with our own strengthens our conviction that an understanding of metaphor can be attained that is independent of the means used to attain that understanding.

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Footnotes

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[1]The research described in this part has been done as a collaboration between Roger Tourangeau and Robert Sternberg (see Tourangeau & Sternberg, forthcoming).

[2]Our thinking about the approach to metaphor has been influenced by the notions of others as well, including those of interaction between tenor and vehicle (Black, 1962) and of basic natural categories (Rosch, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976).

[3]Although the spatial representation described here has provided a useful theoretical basis and heuristic for our thinking about metaphor, we believe it likely that the theory could be mapped into other forms of representation as well, such as a feature representation (Tversky, 1977) or an attribute-value representation (Sternberg, 1977a, 1977b).

[4]Dimensions may correspond in the sense that a common label applies to them. The dimensions are not viewed as equivalent, however: "Prestige" in the domain of modern world leaders may not mean the same thing as "prestige" in the domain of mammal names.

[5]Factor analyses were performed via principal-factor solutions rotated to the varimax criterion.

[6]The research described in this part has been done as a collaboration between Georgia Nigro and Robert Sternberg (see Nigro & Sternberg, forthcoming).

[7]The metaphor may also be set up so that inference occurs in the vehicle and application in the tenor. The nature of the task determines the order of processing.